



# ◀ FISH PASSAGE 2015 ▶

International conference on river  
connectivity best practices and innovations

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## Assessing longitudinal connectivity affected by cross-sectional barriers in a riverine bidirectional graph.



Grupo de Hidrobiología

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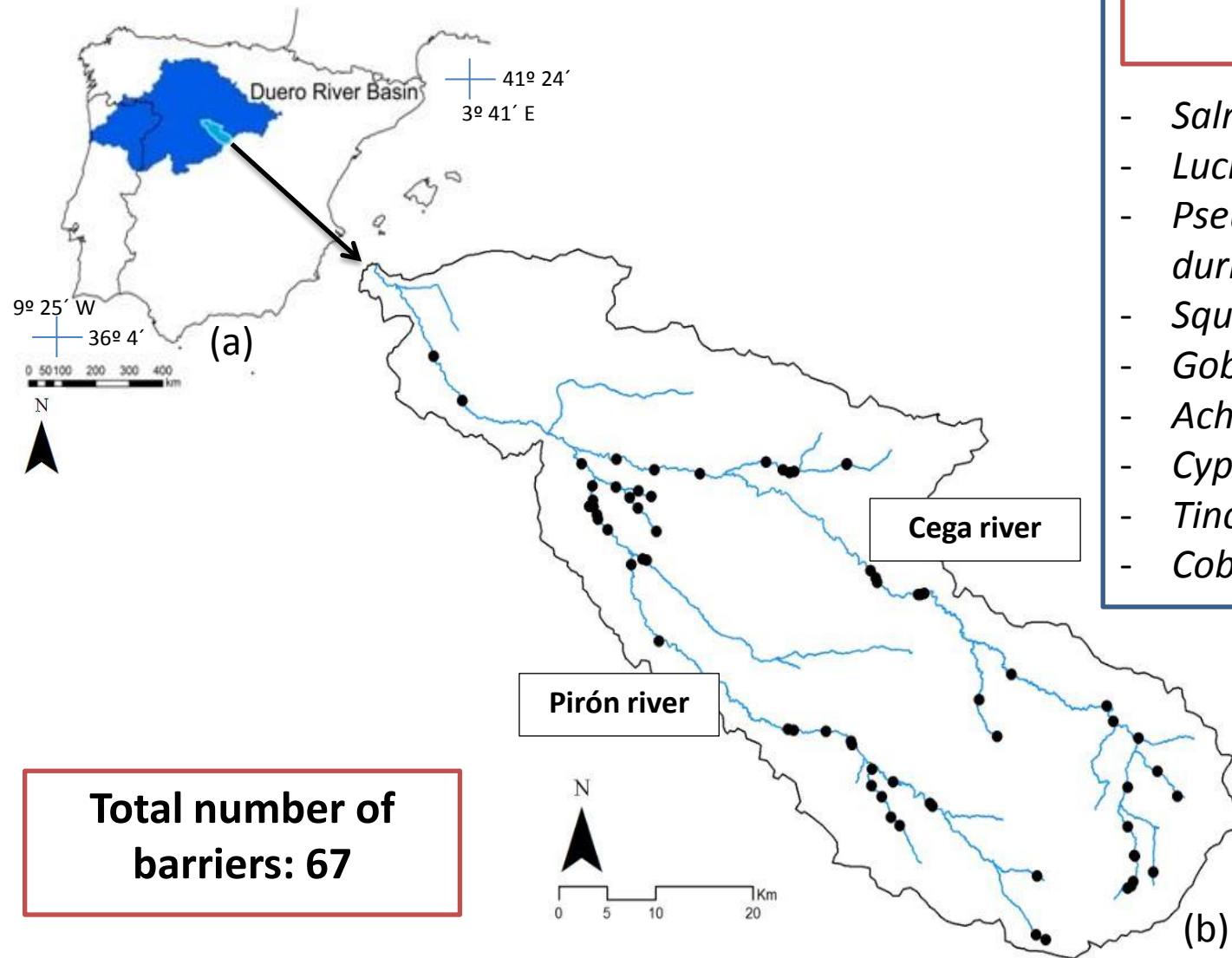


## The importance of longitudinal connectivity in rivers

- **Alteration of longitudinal connectivity** in fluvial systems by the presence of **artificial barriers**.
- There is a **need to restore longitudinal connectivity** in riverscapes in order to meet the good ecological status.
- Challenge: **deal with short budgets** in restoration strategies trying to **reach the maximum cost-benefit ratio**.

1. Quantifying the **loss of global connectivity** in a basin network due to the presence of barriers.
2. Prioritizing the **target river segments to be preserved** and the **obstacles to be removed** for connectivity conservation and restoration purposes.

## Study area and fish species



### Fish species

- *Salmo trutta*
- *Luciobarbus bocagei*
- *Pseudochondrostoma duriense*
- *Squalius carolitertii*
- *Gobio lozanoi*
- *Achondrostoma arcasii*
- *Cyprinus carpio*
- *Tinca tinca*
- *Cobitis calderoni*

**Total number of  
barriers: 67**

## Connectivity tools



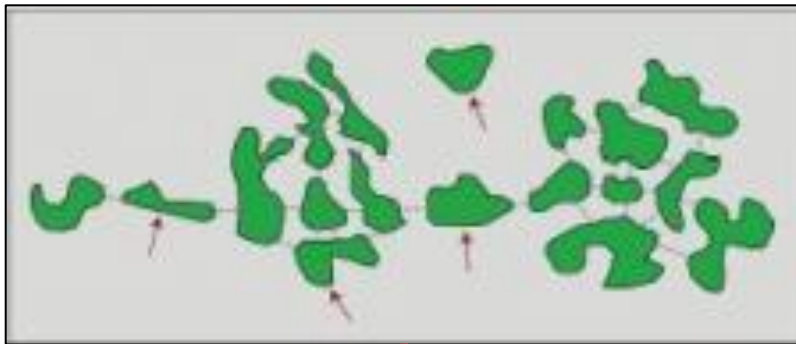
# Conefor

Quantifying the importance of habitat patches and links for landscape connectivity

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- Developed by Saura and Torné in 2009

Software package that **allows quantifying** the **importance** of **habitat areas** and **links** for the maintenance or improvement of landscape connectivity



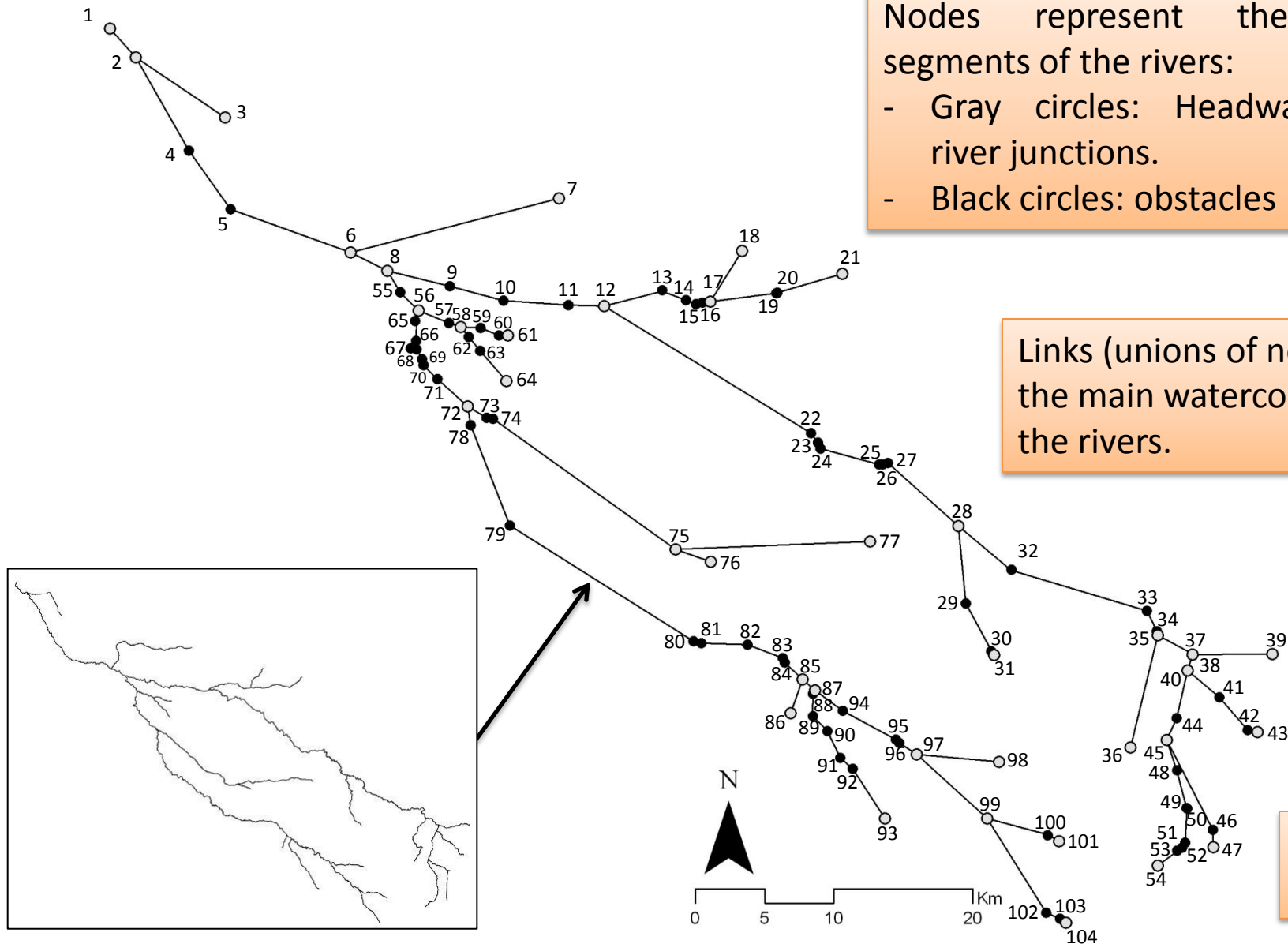
Can we apply this idea to fluvial connectivity?

### Inputs:

- Graph representation of the fluvial network
- Passability value of each obstacle

Free download at  
[www.conefor.org](http://www.conefor.org)

## From a fluvial network to a graph



## Passability value of each obstacle

- Passability Index (PI)\*

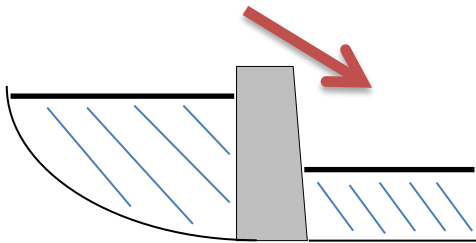
$$PI = P_{\text{upstream}} + P_{\text{downstream}} \quad (\text{for each fish species})$$

**PI = 100** → Insurmountable.

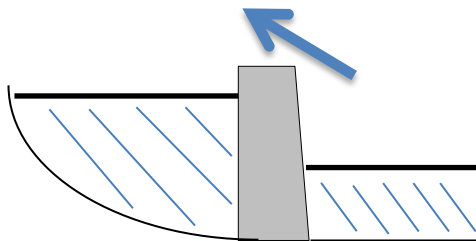
**PI = 0** → Totally surmountable.

**Intermediate values of PI** → crossing depends of flow conditions and the characteristics of the fish species.

Downstream passability

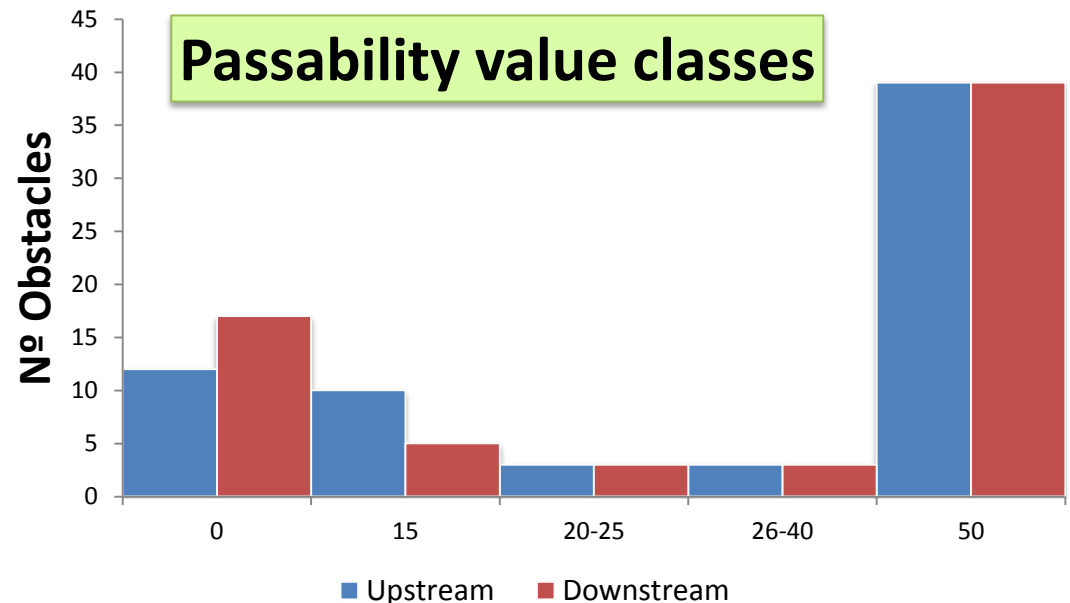


Upstream passability



\* (González Fernández *et al.* 2010)

### Passability value classes





## Attribute values for nodes and links

Habitat attribute value: **river segment length x mean width** (*Erös 2011, Segurado 2013*)

Link value between nodes:

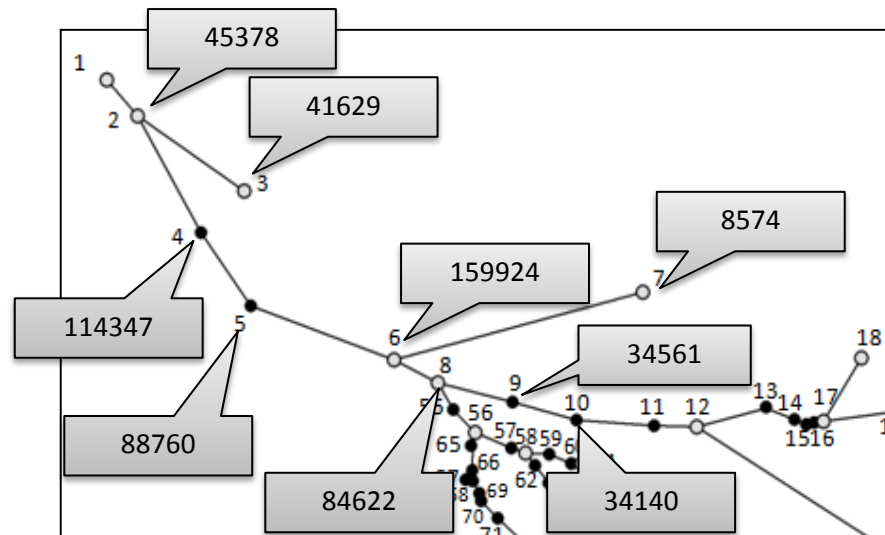
- $PI = 100 \rightarrow$  passability probability = 0
- $PI = 0 \rightarrow$  passability probability = 1

### Ascent

From node	To node	
1	2	1
2	3	1
2	4	0
4	5	0.2
5	6	1
6	7	1
6	8	1
8	9	0
9	10	0
10	11	0
11	12	1
12	13	1
13	14	1
14	15	1
15	16	0
16	17	1
17	18	1
17	19	1
19	20	1
20	21	1
12	22	0
22	23	0
23	24	0
24	25	0
25	26	0

### Descent

From node	To node	
2	1	1
3	2	1
4	2	0
5	4	0.4
6	5	1
7	6	1
8	6	1
9	8	0
10	9	0
11	10	0
12	11	1
13	12	1
14	13	1
15	14	1
16	15	0
17	16	1
18	17	1
19	17	1
20	19	1
21	20	1
22	12	0
23	22	0
24	23	0
25	24	0
26	25	0






## Connectivity index: PC

- Probability of Connectivity Index (PC\*): probabilistic and asymmetric model.

$$\mathbf{dPC} = \mathbf{dPC}_{\text{intra}} + \mathbf{dPC}_{\text{flux}} + \mathbf{dPC}_{\text{connector}}$$



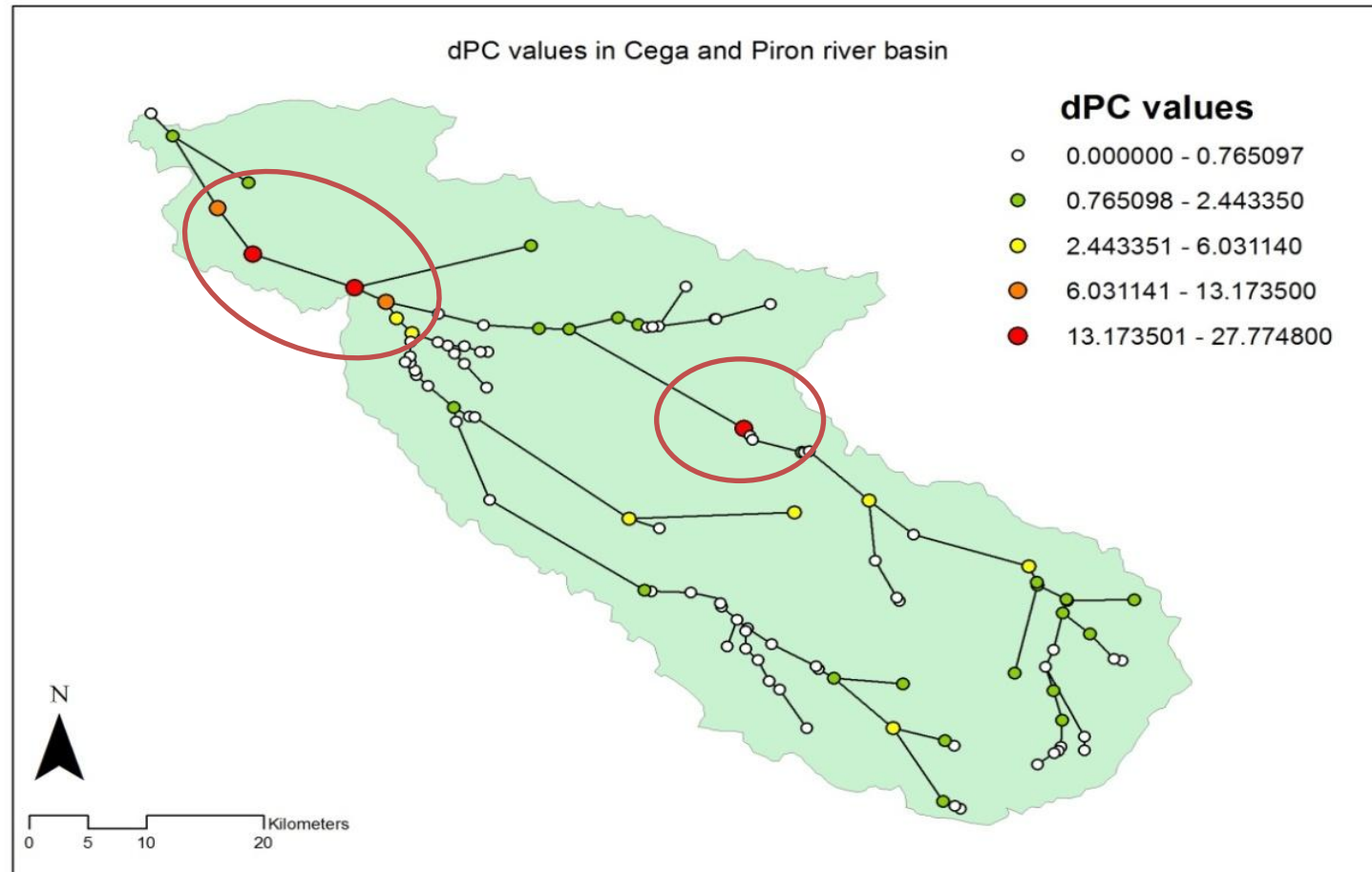
Measures the variations of contribution of each fragment to total connectivity and habitat availability.



**dPCconnector** indicates the patch contribution to general connectivity as a connecting element or “stepping stone” between other habitat patches.

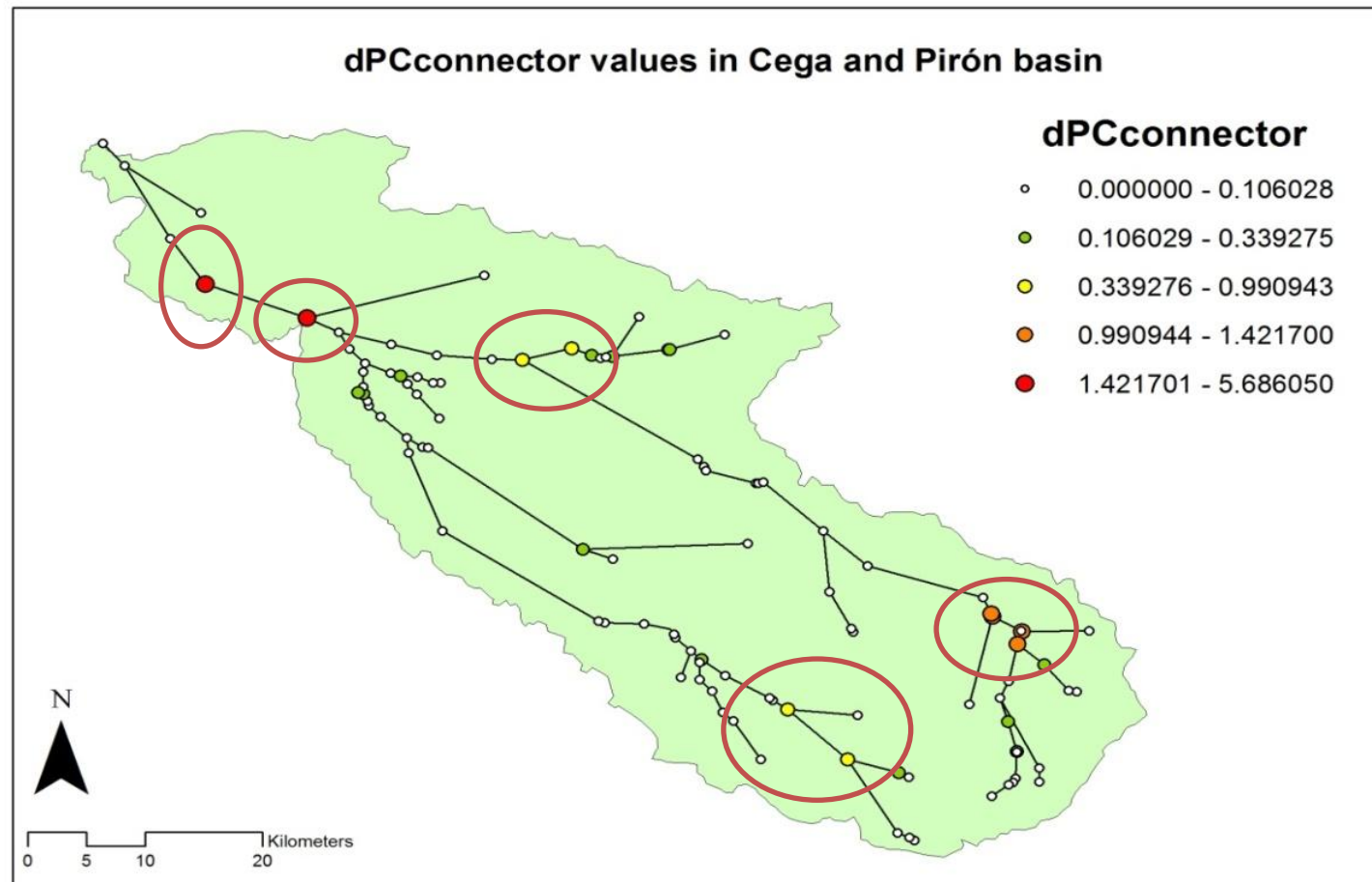
## Prioritizing river segments

Node	6	22	5	8	4	75	28	77	33	55	56	99	34	13	80	12	40	11	36	7
dPC	27.77	19.91	17.78	13.17	8.51	6.03	5.02	4.5	4.17	3.31	3.12	2.82	2.44	2.21	2.16	1.94	1.64	1.61	1.49	1.48



# Prioritizing river segments

Node	6	5	38	40	35	34	12	99	97	13	41	75	20	17	14	48	68	50	67	58
dPCconn	5.68	4.04	1.42	1.35	1.32	1.19	0.99	0.76	0.69	0.59	0.33	0.29	0.28	0.27	0.26	0.2	0.18	0.17	0.171	0.16



## The importance of connections: *link improvement*

*Link improvement* will calculate the positive potential impacts of **improving** as much as possible the **direct connection between each pair of nodes** (only one at time).

The idea is to assign **values of 1 to the connection of each pair of nodes**, which means that the strength or frequency of use of the direct connection between two river segments, *i* and *j*, will be improved for all the pairs of patches.

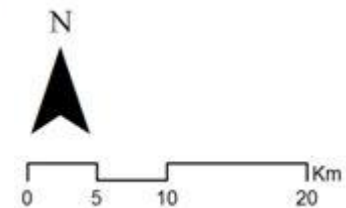
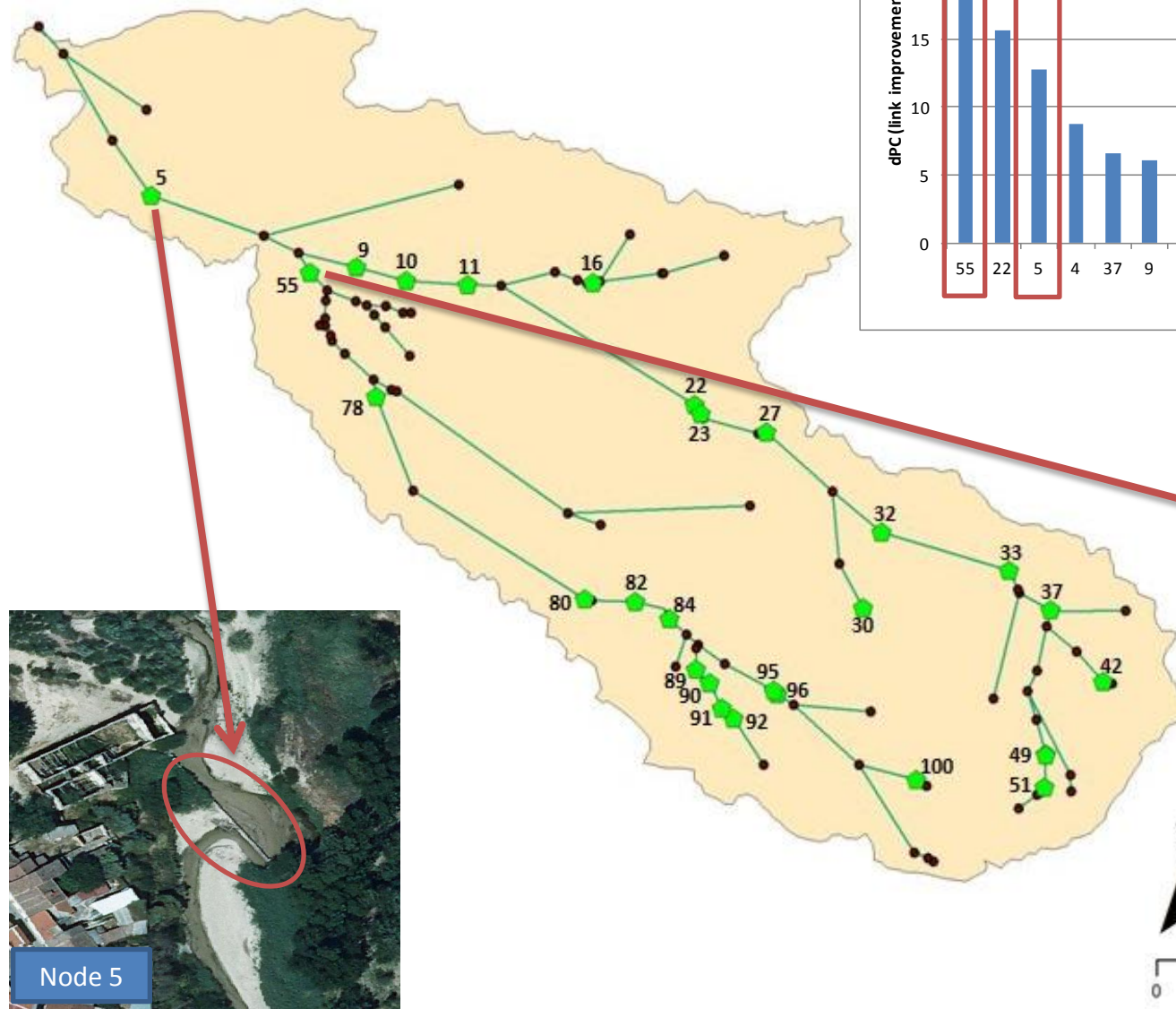
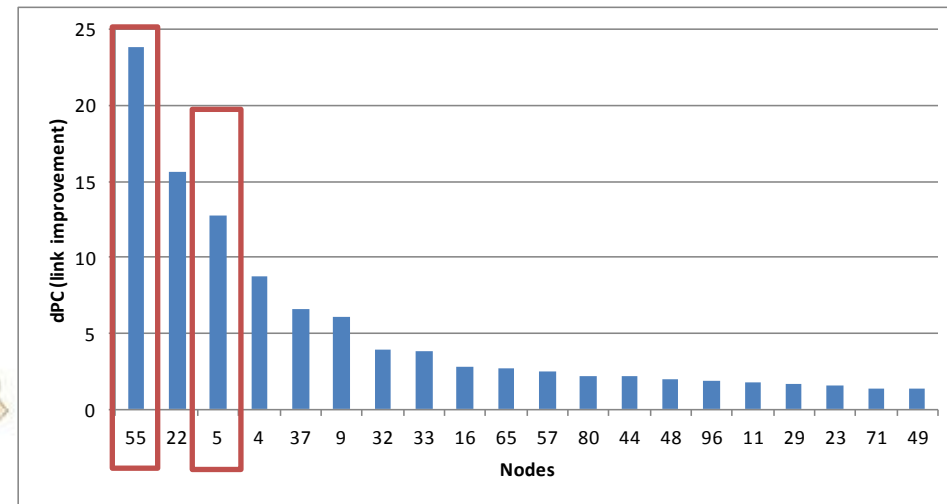
Examples:

PI = 70 → probability of passability = 0.3 → quite far away from 1

PI = 15 → probability of passability = 0.85 → easier to reach 1

In a riverine network, we only take into account **the pair of segments with direct connection** between them.

## Barrier ranking



The tools developed for terrestrial connectivity could be **implemented successfully in fluvial connectivity.**

Graph modeling allows us to quantify the **loss of global connectivity and the most sensitive river segments** to its interruption.

Barriers will be **prioritized** with the aim to develop **efficient management and intervention plans** in which the **minimum possible actions recover high values of connectivity.**



THANKS FOR YOUR  
ATTENTION

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